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Patent Application

of

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for

FLUID COOLING DEVICE

Field of the Invention

The present invention relates to a fluid cooling device as a structural unit with a drive motor driving a rotating fan wheel in a fan housing. At least one fluid can be conveyed from a reservoir tank into a hydraulic working circuit which basically heats the fluid in operation and which leads to an assigned heat exchanger from which the cooled fluid returns to the reservoir tank.

Background of the Invention

EP 0 968 371 B1 discloses a generic fluid cooling device with a trough-shaped reservoir tank configured as an oil tank that partially encloses the drive motor and the assigned fluid pump with high-drawn trough edges in the manner of a half shell. Between the high-drawn trough edges of the reservoir tank, a housing part of sheet metal material holds the fan wheel and forms an air guide shaft for the heat exchanger through which the fluid is routed. In an extension of the housing part in the known solution, underneath the reservoir tank, a base part for the purpose of mounting the device is designed as a shoe. The sole side has mounting bridges at least partially beyond the sole length. This known solution yields a relatively large-volume reservoir tank as an oil tank which saves space in a compact design as a component of the fluid cooling device designed as a structural unit in that the tank reservoir at least partially encloses parts of the device in a space-saving manner. On the basis of the installation space left open by the trough edges, easy

accessibility of the motor and fluid pump unit is ensured for purposes of installation and maintenance. Moreover, as a result of the base part, reliable, space-saving attachment of the entire fluid cooling device to stationary components and housing walls is possible.

The sheet-metal housing part forms the fan housing for the fan wheel, drivable by the drive motor. On the one hand, the housing part is cost-intensive to produce due to the diversity of parts. On the other hand, during operation of the fan wheel, vibrations can be transmitted to the sheet-metal housing part with unintended resonance effects. The sheet-metal housing is also hardly suited for damping fan noise during operation, so that operation of the known fluid cooling device is relatively loud. Due to the sheet-metal construction of the housing part, in part sharp transitions and shoulders are within the air guide so that as a result of turbulence the free air flow in the area of the fan wheel is adversely affected. This result in turn has an adverse effect on the cooling performance of the respective heat exchanger.

Summary of the Invention

An object of the present invention is to an improved fluid cooling device, while retaining conventional advantages, reducing the production and operating costs while simultaneously reducing noise.

This object is basically achieved by a fluid cooling device where parts of the reservoir tank at least partially enclose the fan wheel. The fan housing, which preferably is formed of a plastic material, is designed as part of the reservoir tank. The complex sheet metalworking for producing a fan housing according to the known solution is eliminated. In contrast to the known sheet metal parts solution, the fan housing, preferably made of a plastic material, allows improved damping for fan wheel noise. This dampening applies especially when the reservoir tank, with the fan housing, is filled with fluid. This arrangement further improves the damping behavior. As a result of making the fan housing of plastic material, the configuration possibilities within the scope of production processes for conventional plastic articles are expanded and increased. Sharp transitions in the area of the air guide are avoidable. Continuous, uninterrupted air guidance prevents turbulence and flow

losses, improving energy consumption and reducing the overall operating costs with the fluid cooling device according to the present invention.

In one preferred embodiment of the fluid cooling device of the present invention, the drive motor drives at least one fluid pump mounted on a shaft line jointly with the rotating fan wheel, and/or the fluid pump is provided with its own drive as a component of the fluid cooling device elsewhere. In the initially mentioned possibility, the respective pump is integrated in a space-saving manner in the motor-pump-fan shaft line. For a different embodiment, it is provided elsewhere on the fluid cooling device, for example, is seated on the tank with its own drive. Furthermore, the cooling system of the present invention can integrate the pump into the hydraulic working circuit at a suitable location. In this way, fluid circulation is provided between the fluid cooling device and other components of the hydraulic working circuit.

In one preferred embodiment of the fluid cooling device of the present invention, the reservoir tank has a bottom-side trough part on which an upright-side trough part is seated and is integrally connected to the bottom-side trough part. These trough parts form a hollow collar in which the fan wheel is rotatably mounted. The bottom-side trough part is used especially for reliable and functionally dictated fixing of the entire fluid cooling device on machine parts. It is also possible to place the fluid cooling device directly on the ground, a machine frame, or the like in a self-supporting manner. Conversely, the upright-side trough part forms a holding possibility for the fan wheel which can be integrated in a space-saving manner into the reservoir tank. Proceeding from the upright-side trough part, a holding possibility is created for the drive motor, for the fan wheel in addition to the respective fluid pump and assignable piping. Preferably, it is furthermore provided that the hollow collar delimits a first opening cross section covered by the respective heat exchanger. A second opening cross section in the collar can face the drive motor for the fan wheel.

In one especially preferred embodiment of the fluid cooling device of the present invention, the opening cross section of the hollow collar facing the respective heat exchanger is chosen to be larger in cross section than the cross section of the opening cross section facing the drive motor. The pertinent change in cross section takes place continuously, in particular, by tapering air guide

surfaces. This arrangement yields a smooth, continuous cross section transition between the inflow opening and outflow opening of the hollow collar with the drivable fan wheel, so that a directed flow free of turbulence is largely obtained. This flow benefits fan wheel operation in terms of energy and is favorable for the overall energy balance of the fluid cooling device. The cross section can result from a round diameter or from a rectangular, especially also square diameter, and from sectioned segments of round diameter components and those extending in a straight line.

In another preferred embodiment of the fluid cooling device of the present invention, the upright-side trough part in the area of one free end of the trough-side trough part is mounted vertically to stand on it. The longitudinal extension of the bottom-side trough part corresponds at least to the overall length of the respective fluid pump, in addition to the drive motor. In this way, the static strength of the cooling device is ensured to an especially high degree. Also, the drivable components of the fan wheel, fluid pump, and drive motor are components of the trough parts and accordingly of the reservoir tank such that possible vibrations during operation of the cooling device can be controlled reliably and failure-free, and are transferred to the trough parts.

In another, especially preferred embodiment of the fluid cooling device of the present invention, the reservoir tank has at least two tank chambers at least partially separated from each other. A respective definable amount of an assignable fluid supplies one hydraulic working circuit at a time can be stored in each chamber. By preference, for each amount of fluid separated in the reservoir tank by the individual tank chambers, an independent heat exchanger and an independent fluid pump are provided. In this way, at least two quantities of fluid of the same or different type can be stored in the reservoir tank, delivered to a hydraulic working circuit by its respective fluid pump, and can be cooled by an assigned heat exchanger after traversing the working circuit. The fluid is conventionally hydraulic oil, but can also be cooling and operating media such as a water-glycol mixtures or the like. Thus, it is possible to store and cool several amounts of fluid with only one fluid cooling device.

Other objects, advantages and salient features of the present invention will become apparent from the following detailed description, which, taken in conjunction with the annexed drawings, discloses a preferred embodiment of the present invention.

Brief Description of the Drawings

Referring to the drawings which form a part of this disclosure:

FIG. 1 is a schematic perspective top view of a rear area of a fluid cooling device according to one embodiment of the present invention; and

FIG. 2 is a schematic perspective front view of the reservoir tank, as is used in a fluid cooling device of FIG. 1.

Detailed Description of the Invention

The fluid cooling device of the present invention shown in Figure 1 in its entirety is designed as a structural unit and can be commercially produced as such. In particular, the fluid cooling device of the present invention as shown in FIG. 1 can be integrated into the existing hydraulic circuits of propulsion machines or machine tools to effect fluid cooling of an operating medium, for example, in the form of hydraulic oil. FIG. 1 shows the normal installation position of the fluid cooling device mounted vertically in this installation position on parts of a plant floor or the like. However, it can also be attached to machine and plant parts by its free side surfaces on the latter.

The fluid cooling device has an electric motor 10 of conventional design which drives a fan wheel 12 with individual fan wheel blades and two fluid pumps 14, 16, all jointly mounted along the same shaft line. The respective fluid pump 14, 16 by a removal line 18 removes an assignable fluid, for example, in the form of hydraulic oil, water-glycol or the like, from the reservoir tank 20 and pumps the fluid by ports 22 into the piping or conduits of a hydraulic working circuit (not detailed) to which, for example, a machine tool or a hydraulically actuated operational device is connected. Preferably, each fluid pump 14, 16 is assigned an independent hydraulic circuit. In the

respective hydraulic working circuit, the fluid basically heats up accordingly, and is then recooled to a definable temperature value by the fluid cooling device. This cooling is done for each of the two circuits by a heat exchanger 24 (cooler) of conventional design from which the fluid which has been supplied by connecting points (not shown) can be returned to the reservoir tank 20 by discharge lines 26. The fan wheel 12 with the electric motor 10 is designed as an axial intake fan in which the air is intaken by the fins (not shown) of the respective heat exchanger 24 by the fan wheel in the direction of the electric motor 10 which in this way acquires additional cooling along its cooling ribs by the air flow. As viewed in FIG. 1, the air flow travels from right to left through the fan wheel 12. The fan wheel can be modified to operate the fluid cooling device shown in FIG. 1 as an axial pressure fan with the reverse flow sequence, if this should be feasible for practical purposes.

In contrast to the described embodiment, the possibility also exists of circulating an amount of fluid into and out of the reservoir tank 20 with only one fluid pump or more than two fluid pumps. One or more fluid pumps can convey only one medium, for example, hydraulic oil. It is also possible to convey different media in different circuits, e.g., in addition to hydraulic oil a cooling medium, for example, in the form of water-glycol mixtures or the like. This separation of fluid amounts is described in greater detail below. The reservoir tank 20 is formed of a plastic material, preferably of a polyethylene plastic material (LLDPE), and is produced preferably in one piece in a rotational molding process. As shown in FIGS. 1 and 2, parts of the reservoir tank 20 form the fan housing 20 which, as shown in the prior art, is not formed in this way from sheet metal parts, but from the indicated plastic materials. The fan housing 28 as part of the reservoir tank 20 forms a hollow chamber enclosing the fan wheel 12 on the outer circumferential side with a definable radial distance, and otherwise has a box-shaped structure to the outside or outer configuration.

The reservoir tank 20 has a bottom-side trough part 30 on which an upright-side trough part 32 is placed and is integrally connected to the bottom-side trough part 30. These two trough parts 30, 32 form a hollow collar 34 in which the fan wheel 12 is rotatably mounted. The bottom-side trough part 30 has a square bottom surface 36. Facing forwardly in FIG. 1, a rear side surface 38 and two lateral terminating surfaces 40 transition by a hollow chamber-like gradation 42 into the

lateral boundary surfaces 44 of the upright-side trough part 32. Between the two gradations 42, the upper bottom plate of the bottom-side trough part 30 extends parallel to its bottom surface 36. For the bottom side trough part 30, a type of hollow plate-like base structure is formed on which the two gradations 42 are placed on the edge side in the same manner as the upright-side trough part 32 on one free end area of the bottom side trough part 30 which is opposite the rear side surface 38. In the upper bottom plate 46, there are two obliquely extending notches 48, each provided with a marking 50, permitting readability of the maximum and minimum fill level in the reservoir tank 20 in the direction from overhead. The drive motor 10 extends overhead between the two notches 48 so as not to adversely affect readability. If the upright-side trough part 32 is likewise to be provided with fluid, it is a good idea to provide fill level markings 50 laterally and in turn easily accessible and readable on the two lateral boundary surfaces 44 in the top area. Furthermore, reversible openings are provided with end plugs 52 in the upper bottom plate 46 which facilitate cleaning of a tank or container from the outside after their removal.

The hollow collar 34 has a first opening 54 covered by the heat exchangers 24. FIG. 2 does not show the heat exchangers 24, for purposes of better representation. The heat exchangers 24 are supported in the installed state on the front side 56 of the reservoir tank 20 and cover the first opening 54, having a first cross-sectional area, of the fan housing 28 which is designed as a hollow collar. The hollow collar 34 has another second opening 58, having a second cross-sectional area opposite the first opening 54, and facing the drive motor 10 for the fan wheel 12. In the area of the second opening 58, a hollow cylinder and the wall thickness range of the hollow cylinder is designed such that the blades of the fan wheel 12 move driven circumferentially by the drive motor 10 with a definable radial distance along the hollow cylindrical second opening. Opening 54 of the hollow collar 34 faces the heat exchangers 24, and is greater in diameter than the diameter of the opening 58 facing the drive motor 10.

The cross-sectional change (compare FIG. 2) takes place continuously, especially by tapering air guide surfaces 60. As a result of these air guide surfaces 60, the rectangular cooler shape of the heat exchangers 24 changes continuously to the circular shape of the fan wheel 12. On the one hand, the alignment of the air flow is thereby improved, and the complete air stream also

flows through the corners and edge areas of the heat exchangers 24. The problem known in the prior art is that, due to the design of the fan housing 28 as sheet metal housing parts, the fan diameter corresponds to the inner circle of the rectangular cooler (heat exchanger), inadequate superficial air flows through the corner areas of the heat exchanger 24. This problem is solved by the present invention without having to install an oversized fan (fan wheel) with a diameter corresponding to the imaginary outside circle of the otherwise rectangular cooler, for which proposals can likewise be found in the prior art. This optimization according to the fluid cooling device of the present invention leads to smaller structural space with higher power density. At the same time, a lighter structural shape than in the known solutions is attainable. The cross-sectional change need not be present over the entire area of the hollow collar 34 in the front area of the inflow direction. Rather, transitions can extend in a straight line, especially in the area of the lateral boundary surfaces 44. It is important that quasi-continuous air guidance between the cross section of first opening 54 and the cross section of second opening 58 is achieved.

In the reservoir tank 20, its bottom-side trough part 30 and its upright-side trough part 32 form the fan housing according to the present invention. The noise propagation of the fan wheel is then greatly damped. The conventional fan noise is markedly reduced. This damping effect can be improved if the reservoir tank 20 is also filled with fluid in the area of the upright-side trough part 32. Furthermore, the air guidance area between the first opening 54 and the second opening 58 with the air guide surfaces 60 can be used as a cooling surface since it is in direct contact with the fluid medium. This solution also greatly increases the tank volume to be stored since the fan housing 28 can now be used as additional tank volume.

The upright-side trough part 32 in the area of one free end of the bottom-side trough part 30 is mounted standing vertically on the latter. The longitudinal extension of the bottom side trough part 30 is such that it corresponds at least to the overall length of the respective fluid pump 14, 16 in addition to the drive motor 10 (compare FIG. 1). To fix the position of the latter assembly, in the area of the second opening 58, a holding plate 62 extends transversely over the second opening 58 and is securely joined to the back of the upright-side wall part 32, for example, by a screw connection. To increase reliability, between the holding plate 62 and the actual fan wheel 12, a fan

grating 64 permits passage of air, but otherwise ensures that an operator does not reach unintentionally into the high speed fan wheel 12 when the fluid cooling device is in operation. The longitudinal axis of the electric motor 10 and of the first and second fluid pumps 14, 16 proceeds parallel to the upper bottom plate 46 of the bottom-side trough part 30. The rotary support for the fan wheel 12 is integrated in the holding plate 62 at the same time. The angular configuration of the reservoir tank 20 with the freely projecting electric motor 10 has proven exceedingly vibration-resistant in practical tests. In axial intake air operation of the fan wheel 12, the arrangement allows optimum cooling of the electric motor 10. In this respect, the holding plate 62 has the corresponding recesses 66 to adversely affect the free air passage by the openings 54, 58 as little as possible.

In this embodiment of the fluid cooling device of the present invention, the reservoir tank 20 is divided into two tank chambers 70, 72 separated from each other by a single or double partition wall 68 extending only along the bottom-side trough part 30 in this exemplary embodiment. In each of the two tank chambers 70, 72 a definable amount of an assignable fluid, for example, in the form of a hydraulic medium, is present. However, filling one tank chamber can be filled with one type of fluid, for example, in the form of a hydraulic medium, and the other tank chamber can be filled with another type of fluid, for example, with a coolant in the form of an emulsion which contains water-glycol or the like. Accordingly it is possible to deliver fluid of the same type or two fluids of different type with the two fluid pumps 14, 16 separately from each other. Depending on the respective pump output for the two fluid pumps 14, 16, in this way faster cooling circuit circulation can be achieved. Likewise, the cooling performance can be adjusted by a suitable choice of a heat exchanger 24 and its size. Thus, with the fluid cooling device cooling and optionally also heating tasks to be performed can be carried out across a wide range when the systems are started with a fluid such as a hydraulic medium.

Furthermore, the number of tank chambers (not shown) can be further increased. Preferably, one fluid pump each would be assigned to one or more tank chambers connected to each other, and in the corresponding circuit a corresponding heat exchanger or cooler 24. If the upright-side trough part 32 is to also have a separate chamber volume, the indicated partition wall 68 would

also be implemented accordingly in the upright-side wall part 32. If the partition wall 68 is designed as a double chamber partition wall which optionally forms a recess which can be filled with ambient air toward the bottom surface 36 of the bottom-side trough part 30, especially good heat insulation and reliable media separation between the two chambers 70, 72 can thus be achieved.

The hollow collar 34 as a fan housing 28 on its side 74 facing away from the bottom-side trough part 30 has two tank openings 76 by which the fluid medium can be delivered to the reservoir tank 20. This configuration of the fill openings 76 on the top side of the fluid cooling device is very easy to service due to good accessibility. This service-friendly configuration arises because the fan housing 28 is designed as a tank structure. It has furthermore proven especially advantageous to use a milky-cloudy plastic to permit optical checking of the fill level display for operators or maintenance personnel. The milky cloudiness of the plastic moreover protects the respective fluid medium against ageing, due to ambient light, for example. In particular, the reading possibility using the marking 50 along the notches 48 in the upper bottom plate 46 of the bottom-side trough part 30 has proven advantageous. The reservoir tank 20 can be produced especially economically from polyethylene material in a rotational molding process.

While one embodiment has been chosen to illustrate the invention, it will be understood by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is: